Development and Implementation of Universal Cloud/Radiation Parameterizations in Navy Operational Forecast Models

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LONG-TERM GOALS

Improve the simulation of atmospheric radiation energy fields in Navy operational weather forecast models, such as the current NAVGEM, by the implementation of modern cloud and radiation parameterizations.

OBJECTIVES

1. Design a parameterization for translating prognostic cloud attributes (liquid or ice water content, drop size, layer cloud fraction) in NAVGEM to quantities that will become the input stream to an atmospheric radiation code. Examples are optical thickness, single scattering albedo and fractional cloud overlap.
2. Implement a cloud overlap scheme for NAVGEM.

APPROACH

1. Run a modern radiation code designed for global models, RRTMG SW and LW (Mlawer et al. 1997, Iacono et al. 2008) in off-line mode for clear skies and prescribed cloud properties on local (Purdue University) computers using the default RRTMG cloud prescriptions.
2. Port a Single Column Model (SCM) version of NAVGEM to the local computer for time-stepped runs at two representative grid points. The grid points chosen correspond to Atmospheric Radiation Measurement (ARM) surface sites (http://www.arm.gov/sites) for which observations are available (Oreopoulos and Mlawer, 2010).
3. Conduct sensitivity tests to modify the relationship between cloud microphysics and cloud cover properties and optical properties such as spectral band average optical thickness and single scattering albedo that are appropriate for NAVGEM, i.e. modify the default cloud optical properties prescribed in RRTMG.

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WORK COMPLETED

Objective 1 above has been concluded successfully for prescribed input provided by Dr. Ming Liu of NRL Monterey. We have tested RRTMG on Purdue cluster computer RADON and matched results with NRL for four profiles. The results section following shows a select comparison of input and output. We are now assured that differences in machine and compiler will not be an impediment in the implementation of our off-line efforts into NAVGEM at NRL.

RESULTS

Since we have just started this project, results are available only for the comparison of RRTMG off-line computations for four actual locations and times extracted from the operational model. This initial test was necessary because we wanted to assure ourselves that the bulk of the project and any follow-on could be done at Purdue on our local computer cluster and not require runs at NRL Monterey. For illustration purposes we are showing the comparison of input and output for a tropical location in the Indian Ocean, 60E, 0.5N. Figures 1 through 4 show input parameters to RRTMG whereas Figures 5 through 12 show the output shortwave and longwave radiation fluxes and cooling rates. Results are identical to seven significant figures indicating that our local machines are compatible with NRL machines.

The next step is to port the single column model and actual time step RRTMG through a cycle for a particular location. We have chosen DOE ARM (Atmospheric Radiation Measurement) sites for the SCM. Dr. Liu will send us the code and input parameters shortly. We expect to complete this phase prior to the PI visit to NRL Monterey in December 2013. This pilot project expires at the end of the calendar year. A follow-on proposal will be submitted after consultation with NRL personnel.

IMPACT/APPLICATIONS

The goal of this proposal is for an improved modeling system that can be used for forecasts out to seasonal time scales, as stated in the ONR announcement. The payoff will be improved global prediction systems capable of producing useful monthly and seasonal forecasts. These forecasts would provide valuable guidance on phenomena of particular interest to the Department of Defense.

RELATED PROJECTS

None

REFERENCES

Iacono, M.H., J.S. Delamere, E.J. Mlawer, M.W. Shephard, S.A. Clough, and W.D. Collins, 2008: Radiative forcing by long-lived greenhouse gases: Calculations with the AER radiative transfer models. *J. Geophys. Res.*, **113**, D13103.

Mlawer, E.J., S.J. Taubman, P.D. Brown, M.J. Iacono, and S.A. Clough, 1997: Radiative transfer for inhomogeneous atmospheres: RRTM, a validated correlated-*k* model for the longwave. *J. Geophys. Res.*, **102**, 16,663-16,682.

Oreopoulos, L., and E. J. Mlawer, 2010: The continual intercomparison of radiation codes (CIRC). *Bull. Am. Meteorol. Soc*., **91**, 305-320.

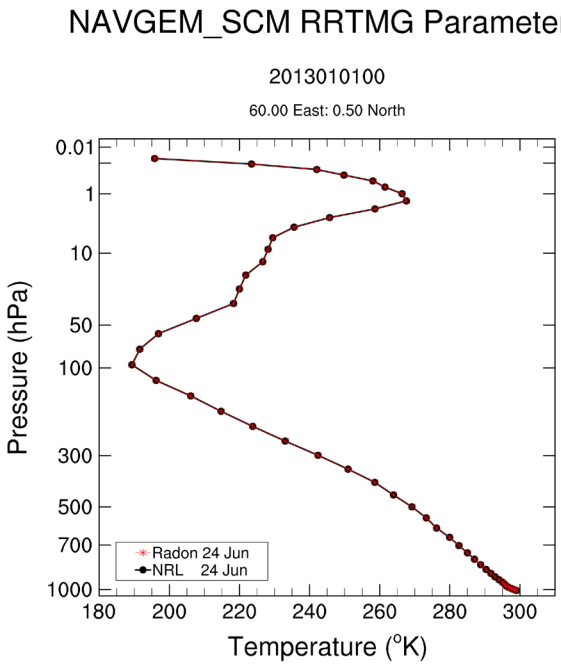

Fig. 1. Input temperature profile

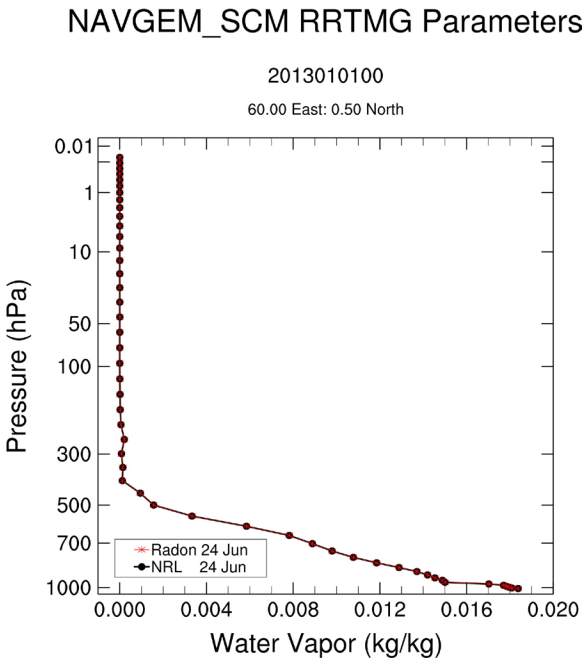

Fig. 2. Input water vapor profile

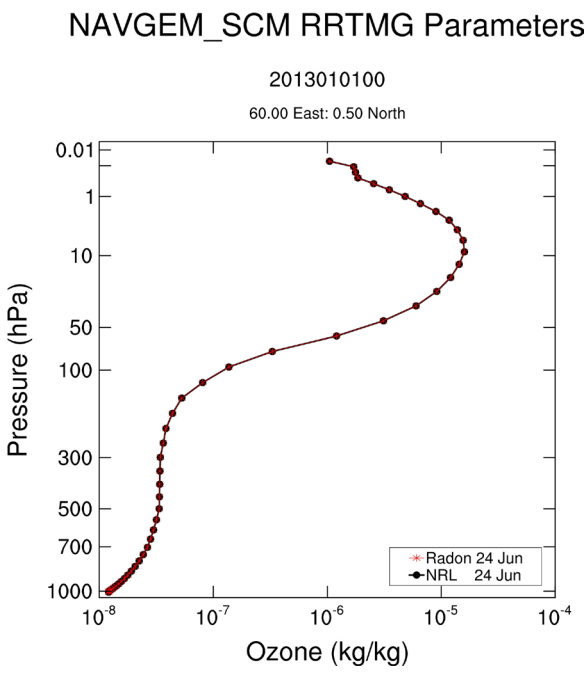

Fig. 3. Input ozone profile

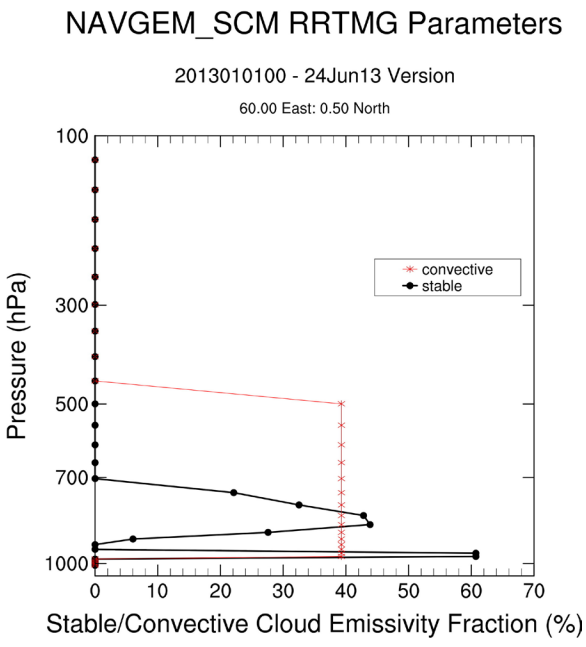

Fig. 4. Input cloud fraction

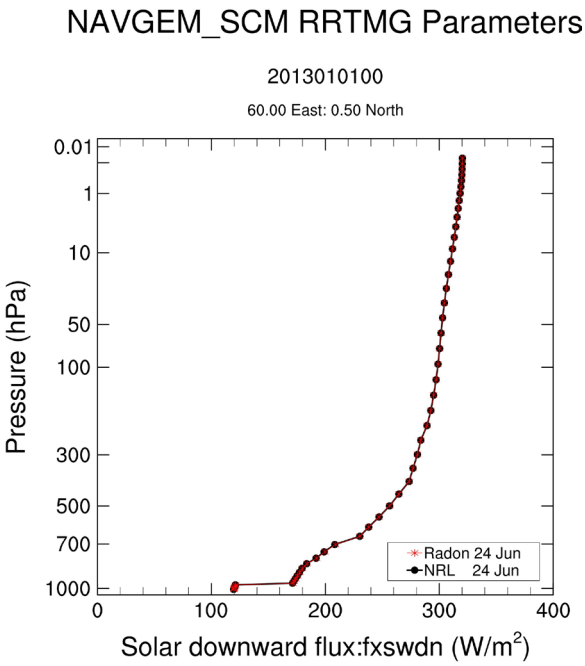

Fig. 5. Downward shortwave flux

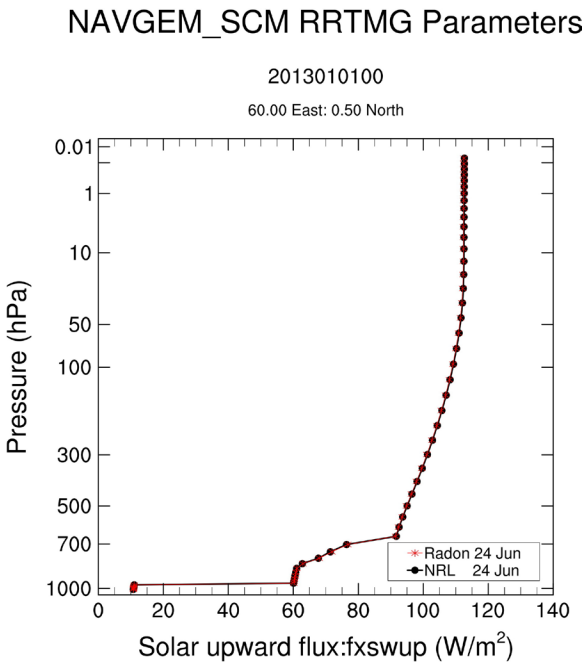

Fig. 6. Upward shortwave flux

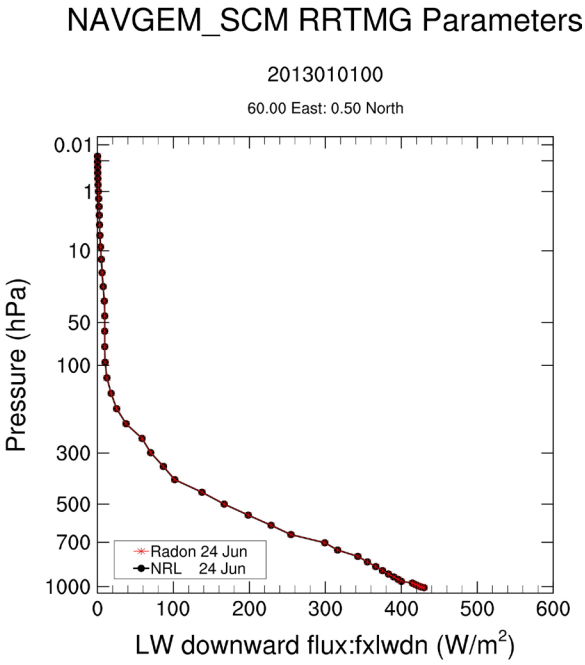

Fig. 7. Downward longwave flux

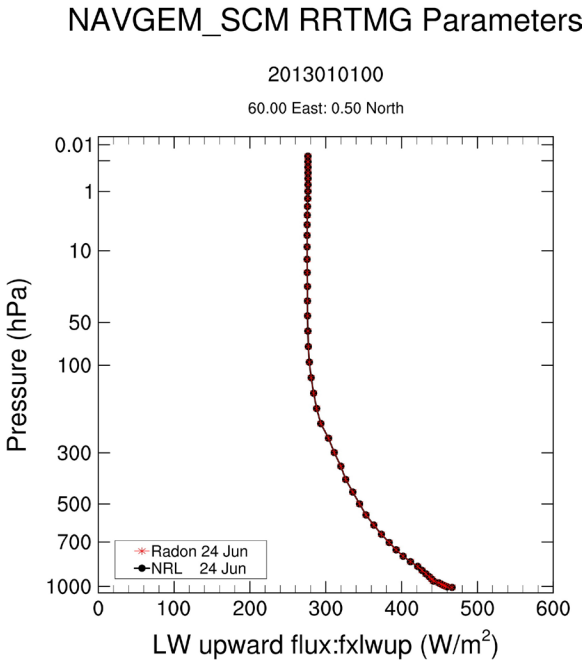

Fig. 8. Upward longwave flux

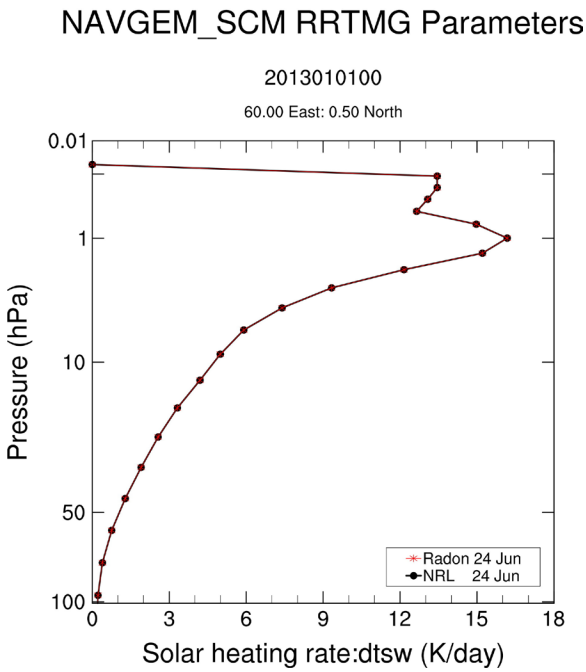

Fig. 9. Shortwave heating rate 100-0.01hPa

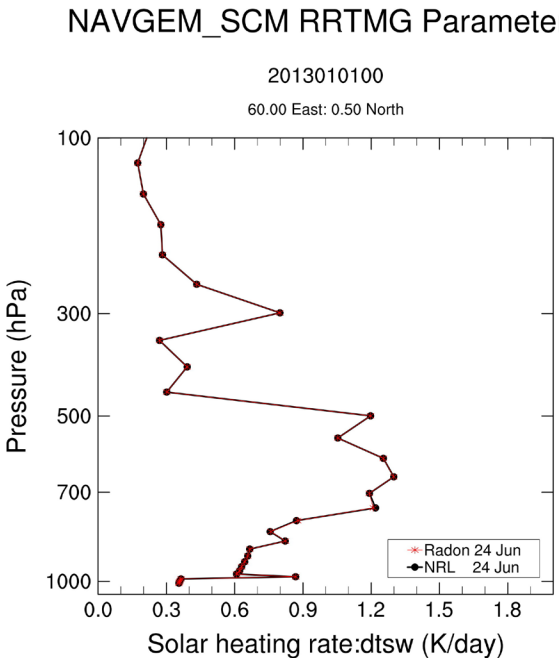

Fig. 10. Shortwave heating rate 1000-100hPa

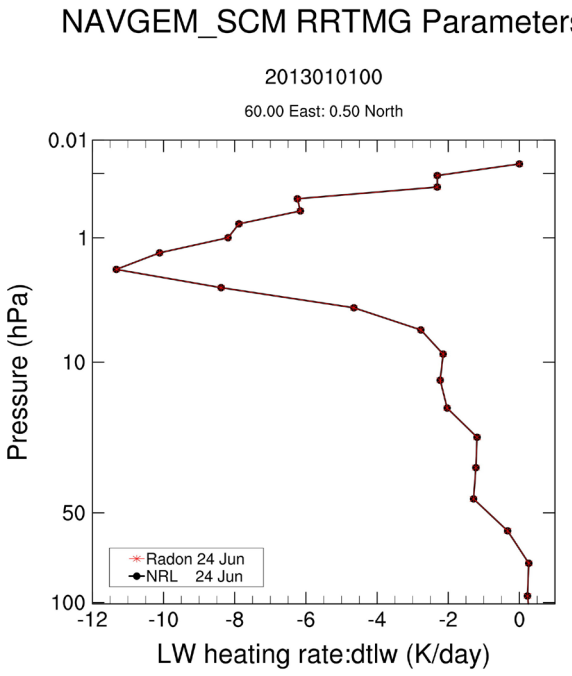

Fig. 11. Longwave cooling rate 100-0.01hPa

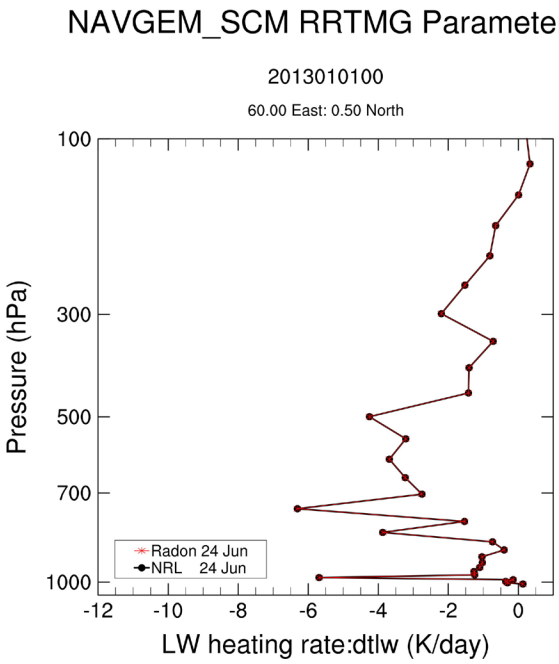

Fig. 12. Longwave cooling rate 1000-100hPa